hanging threads. This palm is now cultivated for ornament in many places in California, and has also been introduced into green-house culture in Europe. An attempt has been made at one place in southern California to utilize a portion of the rough barrens country for an ostrich farm. Ostriches have been introduced from Africa, and are kept in large inclosed tracts, where they have abundant freedom. The climate seems to be quite agreeable to them, and their culture promises success.

Washington, D. C.

The stem of Ephedra.[1]

WALTER H. EVANS.

(WITH PLATE XXI.)

According to Bentham and Hooker, Ephedra occupies an intermediate position between Welwitschia and Gnetum in the order Gnetaceæ. Holding thus a low rank among Gymnosperms, we would expect interesting anatomical structures. In all there are about thirty species, most of which are tropical. Within the United States five or six species have been found, and their range is from Ft. Bridger, Wyoming territory, Colorado and Texas, through Utah, Nevada and Arizona to California.

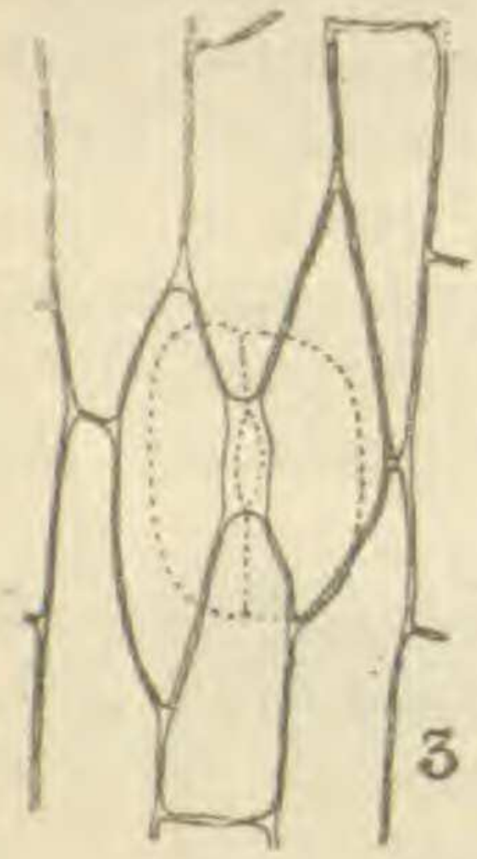
In this study I used the *Ephedra Nevadensis* Wats. and compared with it *E. aspersa* Engelm., *E. pedunculata* Engelm., *E. vulgaris* Rich., *E. trifurca* Torr., and *E. monostachya* L., all of which seemed to differ in no important detail from the type used.

To the casual observer the stem of Ephedra seems to be a jointed affair, branching variously and attaining a height of from six inches to as many feet. He is struck with the close resemblance which the young branches bear to the common horse-tail rush. The stem bears no leaves, but at the nodes of the young shoots are two or three scale-like bracts one to six lines long and usually of a brownish color. In the cases observed, all these scales were deciduous after the first year's growth, while in some cases they were not retained throughout the growing season. These scales are, in all probability, rudimentary leaves, yet they do no leaf work, have no fibro-vascular connection with the stem, and

[1] Contribution from the botanical laboratory of Wabash College.

seem to be but developments of the cortex and epidermis. In the axils of these bracts occur whatever flowers or branches the plant bears.

The epidermis of the stem is rather rough, and is composed of irregularly shaped cells. The outer wall is often considerably cuticularized, frequently becoming half the thickness of the cell. Numerous processes, like very rudimentary trichomes, cover the epidermis, and in optical section give it the appearance of being covered with small knobs. The cortex (fig. 1, *c.*), is for the most part made up of palisade parenchyma, containing chlorophyll. This chlorophyll-bearing parenchyma completely invests the young shoots except at the nodes, where it is abruptly terminated. Within this part of the plant all the leaf work is done. As the stem increases in age the epidermis becomes more cuticularized, the wood tissues encroach more and more upon the cortex, and when from three to five years old its leaf work is over and the stem has lost all resemblance to the rush.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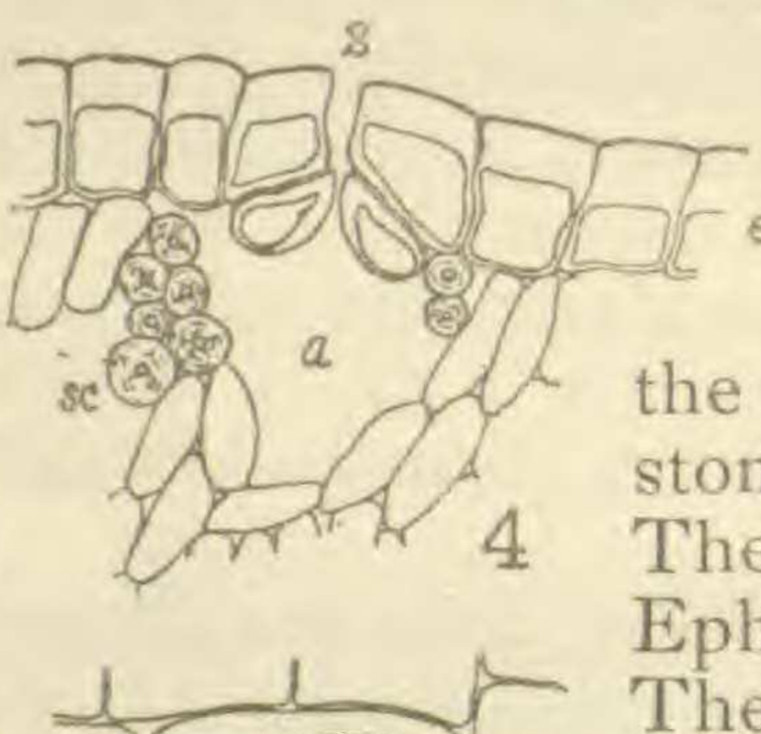

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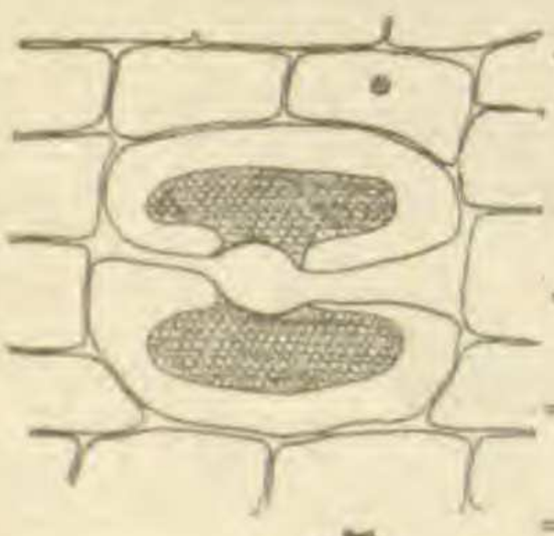
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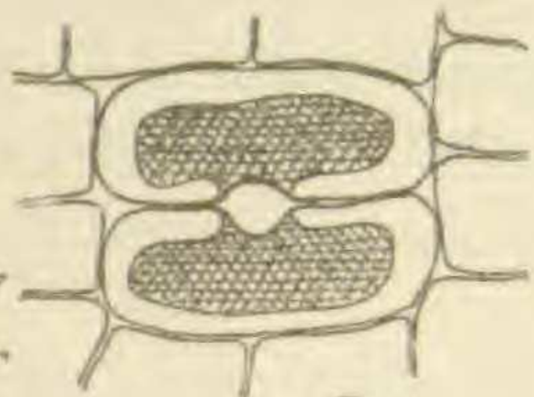
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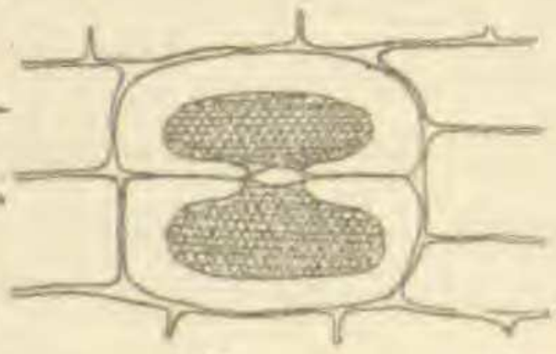
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8

The stoma of Ephedra, x 250.

Arranged either in single or double vertical rows in the epidermis, and leading into the cortex, are found the stomata (fig. 2, *s*, *s*, *s*, etc.). The stomatic structure of Ephedra is a curious one. The opening is formed by four specially developed epidermal cells (fig. 3). Below this opening are placed the guard cells, two in number, and ovate triangular in a central section (fig. 4). By careful manipulation the guard cells may be seen to respond to the presence of water. In fig. 5 is shown a stoma with guard cells wide apart. Fig. 6 shows them partly closed, the extremities of the cells being in contact; while fig. 7 shows them still more nearly closed. Indeed it is only after a long soaking that the slit opening can be entirely closed. Of

course, this process is presumably the reverse of that which would take place were the guard cells in their normal position in relation to the surrounding tissues. In fig. 8 a longitudinal radial section of the stoma is given. Below the stoma the usual air-chamber is found.

Scattered singly or in groups of from two to ten within the cortex, and also the pith, are found very long sclerenchymatous fibers. They are thick-walled and shining. Their length is indefinite, but seems usually to equal that of the internodes. These fibers are much more numerous in the cortex than in the pith. Next within the cortex is found the bundle sheath of very delicate walled cells. Within this is the phloem, containing the sieve vessels and the accompanying cells of soft bast. Next comes the xylem area, resembling that of Pinus very much, having rectangular-shaped cells with heavy lignified walls. The medullary rays are not very prominent even in the most favorable circumstances. Within the xylem area, and forming the central part of the stem, is the pith, of rather large irregular cells.

In my study I used, with good results, chlor-iodide of zinc as a staining fluid. The xylem and the pith take on but little stain, and are seen as yellowish brown. The phloem takes on a very pretty blue, the cortex a darker color, and the sclerenchymatous fibers a beautiful pink. If the sections stand too long in the reagent, the phloem and the parenchyma adjoining it take up so much color that they can not be readily distinguished. No trouble can be met with in distinguishing the characteristic cells of the xylem and the pith.

In longitudinal radial section we get a very similar arrangement of parts as in transverse section. The epidermis, cortex, sclerenchymatous fibers and bundle sheath, except as mentioned already, differ in no respect from the forms usually characterizing such tissues. The phloem is composed of cells of considerable length. They are rather thin-walled and have blunt ends. In the xylem area there are striking differences. Some of the cells are quite long as compared with surrounding ones. These long cells are generally horizontally or spirally banded, and the walls are rather thick (fig. 10, *sp.*). Other cells are shorter, and have the usual tapering ends of all tracheids. Most of these are more or less spirally banded, and have thinner walls. Some in the older wood have the characteristic disk markings of all gymnospermous stems, while others have both the disks and spiral markings. The pith cells are different in no respect from

those found in such stems. However, it often contains a sort of reddish brown coloring matter, a secretion which is soluble in water at ordinary temperatures, showing it can not be "a kind of resin," as has been claimed.

Just above each node, except in E. monostachya, is found a most curious structure. Running across the stem is a sort of diaphragm of three or four cells thickness. This completely cuts off the pith and often the xylem also (fig. 11). Whenever any of the tracheids pierce this they are the long, heavy-walled ones spoken of above. After acting as an almost complete partition in the region mentioned, it seems to merge into the phloem on either side. The cells making up this curious structure are rather thin-walled, and about three times as long as broad. When treated with chlor-iodide of zinc they take the characteristic color of the phloem. Just what the office of these cells can be, I am not prepared to say. They may be active meristem cells, and the growth of the internode may be found in this layer. I found that wherever this exists it forms a line of easy division, and the brittle stems always break at this point. If the other habits of the plant would warrant it, this may be a means for propagation, since by breaking as it does there can be no injury to the node, and if the plant will grow from cuttings this may be nature's way of providing them.

Crawfordsville, Ind.

EXPLANATION OF PLATE XXI AND FIGURES IN TEXT.—Fig. 1. Cross section of stem: *e*, epidermis; *c*, cortex; *b*, bundle sheath; *ph*, phloem; *xy*, xylem; *p*, pith; *sc*, sclerenchymatous fibers; *s*, *s*, *s*, stomata; *a*, *a*, *a*, air chambers.

Fig. 2. Surface section of epidermis, showing vertical rows of stomata.

Fig. 3. Epidermal cells surrounding a stoma.

Fig. 4. Cross section of stoma: *s*, stoma, guard cells below; *a*, air chamber; *e*, epidermis; *sc*, sclerenchymatous fibers.

Fig. 5. Guard cells dry.

Fig. 6. Same, partly closed.

Fig. 7. Same, nearly swelled shut.

Fig. 8. Longitudinal section of stoma.

Fig. 9. Longitudinal section of stem, lettered as in fig. 1.

Fig. 10. Elements in longitudinal view: *sc*, sclerenchymatous fiber; *sp*, long tracheid; *tr*, forms of tracheids; *p*, pith.

Fig. 11. Showing diaphragm above node as in longitudinal section.

Fig. 12. More highly magnified portion of same.

Figures 3—8, × 250; 1, 2, 9, 10, 12, × 125; 11, × 24.